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Real-time Decoding of Emotional States from fMRI Brain Signals

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Introduction:

An important question that confronts current research in neuroscience as well as in the treatment of neuropsychological disorders is whether it is possible to determine the emotional state of a person based on the measurement of brain activity? Development of techniques that answer the above questions in the affirmative help not only to further the progress of affective neuroscience but also in the development of technologies, commercial products and services such as brain-computer interfaces (BCIs), neurofeedback systems, clinical treatment of mental disorders. The aim of this study was to investigate if a brain state recognition system can be built to decode multiple discrete emotional states of the brain from fMRI signals and whether the output from the real-time classifier could be used for providing feedback to the participant.

Methods:

We have developed a real-time brain state detection system based on the support vector machine (SVM) classification of whole-brain fMRI signals for each repetition time of acquisition (TR).

Stage 1: Acquisition of fMRI signals when 7 participants were presented: a) standard pictures from International Affective Picture System (IAPS) known to elicit discreet emotions: neutral, happy and disgust emotions. b) instructions to recall emotional episodes belonging to the 3 categories of emotions (happiness, disgust, neutral). Classifier parameters are then estimated for each participant by using our custom developed SVM toolbox for fMRI data.
Stage 2: Testing the classifier for each participant on new fMRI data acquired during a similar paradigm (as above) involving viewing of emotional pictures or recall of emotions.
Stage 3: Neurofeedback training of emotional regulation using a thermometer feedback based on real-time brain state classification.

Results: Online, real-time classification of the states. Showed an average error rate of 25% for all subjects. In addition, on some subjects, a classifier trained on pictures could classify emotional recall also with more than chance (~70%) accuracy. This shows that there are common areas of activation between stimuli based and recall based emotion induction.

Conclusions:

Our approach demonstrates the application of real-time classification of emotion states in the brain from fMRI signals, and subsequently using the classification to provide feedback information to the subject to modulate his brain activity to enhance or reduce the effect or intensity of the brain state. A major factor that influences the performance of the online classifier, in our experience, is the subject head position when compared between classifier training and testing, and head motion artifacts. Future work should look at improving performance by overcoming these limitations. With regard to applications of online brain state classification, we are now incorporating this technique for detection of covert attitudes and lies, neurofeedback rehabilitation after stroke, and for the treatment of emotional disorders.

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